UNIVERSITI PUTRA MALAYSIA

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By

ACHMAD FAUZI ISA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

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ACHMAD FAUZI ISA

June 2002

Chairman : Associate Professor, Dr Siti Zauyah Darus

Faculty : Agriculture

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Faculty : Science, Ghent University, Belgium

Soils on three toposequences in Anyer, Carita and Saketi areas in Banten Province, West Java, and soil on Rakata island (Krakatau volcano) in Sunda Strait, Indonesia have been sampled for pedogenetic study and classification The soils in Banten developed on the slope of the Quaternary volcanic complex and the sedimentary facies with different annual rainfall and vegetation The objectives of this study were to determine the soil physical, chemical, mineralogical and micromorphological properties, to study the genesis of the soils, to determine the effects of the Krakatau ash and to classify the soils according to Soil Taxonomy and World Reference Base

The results showed that all the soils on the slope of volcanic complex have been strongly weathered to form yellowish brown to red deep soils with high clay content, low pH, low base and various CEC Mineralogical characteristics of these soils consist of dominant kaolinite in the clay fractions, crystobalite and quartz in the silt fractions and opaque minerals in the sand fractions The mineralogical characteristics indicate that most of the soils may be formed from andesitic volcanic ash The

relative higher amount of weatherable minerals with pumice in the surface horizon confirmed that the soils were rejuvenated by fresh volcanic ash from the eruption of Krakatau volcano in 1883. The effects of the Krakatau ash were not shown at the soils on the lower slope of the Saketi toposequence. These soils developed from sedimentary facies which were comprised of acid tuff, claystone and sandstone. These soils are characterised by yellowish brown colour, clay textured B horizons with various sand content with depth, low pH, low base and various CEC.

Pedogenesis processes of these soils were strongly influenced by the parent material, climate and vegetation. Clay illuviation was more evident in the Anyer soils where rainfall is lower compared to Carita and Saketi Soils. In contrast, pedoturbation and homogenisation increase with the wetter climate and forest vegetation in Carita and Saketi. Soils on sedimentary facies in Saketi consist of relatively high quartz sand fraction and more yellow colour than the soils on andesitic volcanic ash. The addition of Krakatau ash in 1883 has caused an increase in exchangeable bases, sand and silt fractions especially in Anyer and higher amount of amorphous materials in the soils at higher elevation of Saketi toposequence. Soils in Anyer were classified as Typic Paleudults according to Soil Taxonomy (Soil Survey Staff, 1999) or Abruptic Acrisols according to World Reference Base (ISSS-ISRIC-FAO, 1998). While in Saketi, the soils which developed on sedimentary facies were classified as Typic Paleudults, but as Profondic Acrisols or Luvisols according to the World Reference Base. Volcanic soils under forest at the lower elevation in Carita can be classified as Andic Tropudults or Humic Acrisols and as Andic Dystrudepts at the higher elevation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEDOGENESIS DAN PENGELASAN TANAH TANAH DI BANTEN, JAWA BARAT, INDONESIA

oleh

ACHMAD FAUZI ISA

June 2002

Pengurusi : Profesor Madya Dr Siti Zauyah Darus

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Satu kajian ke atas tanah-tanah di tiga toposekuens di kawasan Anyer, Carita dan Saketi di Banten Province, Jawa Barat, dan ke atas tanah di Pulau Rakata (Gunung berapi Krakatau) di Selat Sunda, Indonesia telah diambil contohnya untuk penyelidikan pedogenetik dan pengelasan. Tanah-tanah ini telah terbentuk atas cerun kompleks Kuaterner gunung berapi dan fasis endapan yang menerima curahan hujan yang berlainan dan berbeza tumbuhan. Objektif kajian ini ialah untuk menentukan sifat fizik, kimia, mineralogi dan mikromorfologi, mengkaji genesis tanah-tanah ini, mengenalpasti pengaruh bahan abu Krakatau ke atas sifat tanah dan mengelaskan tanah ini mengikut system pengelasan 'Soil Taxonomy' dan 'World Reference Base'

Kajian ini telah menunjukkan bahawa semua tanah atas cerun kompleks Kuaterner gunung berapi telah terluluhhawa membentuk tanah dalam berwarna coklat kekuningan sampai merah dengan kandungan lempung tinggi, pH yang rendah, bes bertukarganti rendah dan KPK julat bervariasi Sifat-sifat mineral pada tanah-tanah ini menunjukkan

bahawa kebanyakan tanah-tanah ini terbentuk daripada abu volkanik andesit. Banyak mineral yang senang terluluhawa dengan pumis dalam horison atas dapat dipastikan bahawa tanah-tanah ini telah menerima bahan abu daripada letusan gunung berapi Krakatau pada tahun 1883. Kesan-kesan daripada abu Krakatau tak ditunjukkan pada tanah-tanah atas cerun bawah Saketi toposekuen. Tanah-tanah ini berkembang daripada fasis endapan yang mengandungi tuf masam, batu lempung dan batu pasir. Tanah-tanah ini dicirikan oleh warna coklat kekuningan, horison B bertekstur lempung dengan variasi kandungan peringkat pasir, pH rendah, base bertukarganti rendah dan variasi KPK julat.

Proses-proses pedogenesis sangat dipengaruhi oleh bahan induk, iklim and tumbuh-tumbuhan. Iluviasi lempung lebih jelas ternampak pada tanah Anyer di mana curahan hujan lebih rendah daripada di kawasan Carita dan Saketi. Sebaliknya pula, gangguan tanah meningkat di kawasan yang lebih lembab dan di hutan seperti di Carita dan Saketi. Penambahan abu volkanik daripada letusan Krakatau pada 1883 telah meningkatkan bes tukarganti, kandungan pasir dan kelodak terutama sekali di Anyer. Kandungan bahan amorfus pula meningkat pada tanah di kawasan tinggi di Saketi. Tanah-tanah di Anyer dikelaskan *Typic Paleudults* mengikut "Soil Taxonomy" (Soil Survey Staff, 1999) atau *Abruptic Acrisols* mengikut "World Reference Base" (ISSS-ISRIC-FAO, 1998). Tanah-tanah daripada fasis endapan di Saketi juga dikelaskan sebagai *Typic Paleudults*, tetapi sebagai *Profondic Acrisols* atau *Luvisols* mengikut "World Reference Base". Tanah-tanah volkanik di kawasan rendah hutan Carita dikelaskan sebagai *Andic Kandiudults* atau *Humic Acrisols* dan sebagai *Andic Dystropepts* atau *Chromic Cambisols* di kawasan tinggi.

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I certify that an Examination Committee met on 13th June 2002 to conduct the final examination of Achmad Fauzi Isa on his Doctor of Philosophy thesis entitled "Pedogenesis and Classification of Soils in Banten, West Java, Indonesia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations that have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

ACHMAD FAUZI ISA

Date: 24 AUG 2002

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CHAPTER 1

INTRODUCTION

Most soils in the Indonesian archipelago are derived from or influenced by volcanic materials. Therefore the distribution and the type of soils formed in this region is strongly affected by the age and the type of volcanic materials, topographical and climatic conditions. Soils derived from volcanic materials are commonly classified as Andisols according to Soil Taxonomy or Andosols according to World Reference Base. However, some studies of volcanic soils in Indonesia showed that Andisols are mainly found at the higher elevation of the young volcanic area. At the lower elevation or on the older volcanic materials the soils have developed with weak or without andic properties and can be classified into other soil orders, such as Inceptisols, Alfisols, Ultisols, and Oxisols (Buurman *et al.*, 1976; Subardja and Buurman, 1980; Subagjo *et al.*, 1984).

In Indonesia, more than 60% of the agricultural products are the result of agricultural activities on the volcanic soils. The intensification and extensification of agricultural development programs that have been conducted by the government in this country have not only increased agricultural products, but have also brought some problems, such as, soil degradation, soil and water pollution, and other environmental quality problems. A basic understanding of the main soil forming factors and soil forming processes of the volcanic soils can be useful not only for soil classification, but also for investigating the consequences of agricultural activities and other land uses.

Banten, located in West Java, Indonesia consists of soils developed on the Old Quaternary volcanic materials and Pliocene sedimentary facies (Geological Survey of Indonesia, 1963). The soils in this area have been classified as Latosols and Podzolic Soils according to Dudal and Soepraptohardjo (1957). The classification was based on poor and rich parent materials, colour, texture, pH and occasionally on organic matter status. This soil classification has a broad definition and implies that the classified soils can be found on wide areas with various kinds of parent materials. Thus a precise soil classification that is more efficient for land use in this area becomes necessary.

A study of volcanic soils in Banten is still needed as the soils developed on the Quaternary volcanic materials in the northern part of Banten are intensively used for agricultural activities. During the Krakatau eruption in 1883, the area had been affected by the Krakatau ash falls (Verbeek, 1885, Mohr, 1944). However, the effects of the Krakatau ash falls on the soil properties is yet unknown. Therefore, a detailed pedogenetic study on the volcanic soils in Banten becomes very important. The results of this study may help solve the soil classification problems and give a precise guide for the agricultural management.

This study emphasised on the characterisation and pedogenetic aspects of volcanic soils in Banten, West Java, Indonesia The objectives of this study are

1. To determine the physico-chemical, mineralogical and micromorphological characteristics of volcanic soils in Banten, West Java, Indonesia,
2 To study the genesis of the soils in relation to parent material, topography and climate,

3. To determine the effects of the 1883's Krakatau ash falls on the soil properties; and
4. To classify the soils according to Soil Taxonomy (Soil Survey Staff, 1999) and the World Reference Base (ISSS-ISRIC-FAO, 1998).